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FINAL REPORT

THE FEASIBILITY OF THE ACQUISITION AND DEPLOYMENT OF A CANADIAN MINES ATMOSPHERE MONITORING LABORATORY

by

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for

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MICROMEDIA

INTRODUCTION

The design of a Mine Air Monitoring Laboratory (MAML) in the United States was undertaken in 1975. The MAML has been used to measure both diesel and blasting pollutants and is presently deployed at the White Pine Mine in White Pine, Michigan. The U.S. MAML was designed and constructed by Bendix under the supervision and guidance of Michigan Technological University in Houghton, Michigan. The MAML is one of the important parts of an overall Mine Air Quality Laboratory (MAQL) operated by Michigan Technological University for the U.S. Bureau of Mines. The MAQL is described in Reference 1.

The mining Research Laboratory requested that we undertake a study to determine the feasibility of developing a Canadian Mine Atmosphere Monitoring Laboratory (MAML) to be deployed in a similar manner in Central Canada. The statement of work for this effort was as follows:

1. To determine, from discussions with CANMET personnel (In Ottawa, and at the Elliot Lake Laboratories), which contaminants should be measured by the Canadian "MAML", and to determine which instrument types are favoured. To recommend, based on the above, a general configuration for the Canadian "MAML".

2. To locate, in Central Canada, a suitable institute which can provide the necessary technological infrastructure to service and operate the "MAML".

3. To locate, taking due account of the recommendations of 2 above, a suitable mining operation with a management willing to co-operate in providing an experimental mine section for the initial deployment of the "MAML".

4. To locate a Canadian contractor or contractors able to undertake the routine aspects of the design, plus all of the construction of the Canadian "MAML".

The study was carried out from July 15, 1981 to March 15, 1982 and involved three visits to Canada. The first was in July 1981 to attend a CANMET internal review meeting in Ottawa, to discuss pollutant monitoring. This served the purpose to acquaint the authors with Canadian mining requirements. The second was in August 1981 to visit several mines and universities in Central Canada. The third was in December 1981 to visit contractors that could design and build the Canadian MAML. This report is an overall summary of our findings, conclusions, and recommendations as a result of this study.

BACKGROUND

As a result of our study of the scope of work for the project, we decided the study could be effectively broken down into the following elements:

- Plan visits and develop criteria for the selection of university and mine
- Visit some universities and mines to gather information
- Write trip report
- Develop MAML configuration and design specifications; develop criteria for evaluating potential contractors
- Visit potential contractors that could design and construct the MAML
- Write trip report
- Write final report and develop recommendations

In August of 1981 we visited several mines and universities in Canada. The purpose of the trip was to obtain information about them in order to develop specific recommendations about the design, construction, and deployment of a Canadian MAML.

With our criteria to guide us, we were able to determine how the future MAML could be deployed relative to the way mining is done in Canada. Factors such as the physical size which would allow the MAML to fit into hoists, and be transported in the drifts, and power availability underground were evaluated and used when the preliminary design for the MAML was made.

Visits to the Universities gave less definative information. The object was to find one that would have the people and resources necessary to carry out a research program involving the MAML. Even though we had developed criteria to judge them by, each school was different enough from the others as to make direct comparisons difficult.

From the information obtained on this trip, we were able to develop design specifications for the Canadian MAML. This preliminary design was organized into a booklet and handed out to the potential contractors (who would design and build the MAML) during our second trip to Canada. Discussions with these organizations and CANMET personnel led to the refinement of the design and allowed us to better specify what types of instruments should be included in the MAML and what their specifications should be.

RESULTS OF STUDY

Mine Visits

In August, we visited several mines in central Canada. These were the Denison Uranium mine, north of Lake Elliot, the Falconbridge mine, INCO's South mine, and the Big Nickel mine, all in the Sudbury area. The objective of these visits was to gain an appreciation for typical mining conditions in Canada, which would affect the design of the MAML. This trip was documented in a trip report to the Technical Project Officer.

In general, the mines in Canada will require a MAML design that differs in two main categories than its U.S. counterpart. The mine entrances were typically smaller (the INCO mine at Sudbury has cage dimensions of 58 in. wide x 81 in. high x 12 ft. long and the Falconbridge mine has cage dimensions of 66 in. wide x 120 in. high x 13 ft. long), and the power used in all the mines we visited was 575 volts, 3 phase A.C., which is different than that used in the U.S.

Criteria for the selection of a mine for initial deployment were as follows (Appendix A):

1. Management's attitude about research and government work
2. Representative of typical mining operations in Canada
3. Good entry to mine for equipment
4. Area suitable for study
5. Equipment availability
6. Short distance to University

Taking all factors into account, the South mine (INCO) looked like the best choice for initial deployment. All the criteria were met by this mine, with the possible exception of the last, distance to a University. In this regard, all of the mines visited were in the North, and all the universities except one were in the South and East, quite a distance from the mines. Mine detailed information from these visits is in Appendix B of this report. Another mine which we did not visit on our August 1981 trip which could also be considered is the Ojibway Mine of Canadian Salt Company Limited in Windsor Ontario.

University Visits

We also visited several universities during the August 1981 trip. These were Laurentian University in Sudbury, McMaster University and the University of Toronto, in the Toronto area, Queens University in Kingston, the University of Laval in Quebec City, and McGill University in Montreal. Criteria for the selection of a university were as follows (Apprendix A):

1. Interdisciplinary capability to do research
2. Shop, lab, computer facilities
3. Administrative support and faculty interest, capability to do mine air quality research
4. Location relative to potential mines

We found the selection of an appropriate university to be much more difficult than that of a mine. Even though we had specific criteria to guide us, the diversity of the different schools visited made comparisons difficult. It also was difficult to determine their overall motivation for doing this type of research and how they would pull together and organize a team of researchers. It was concluded that we would seek proposals from the different schools describing how they would handle a research project involving the Canadian MAML. This would allow them to point out strengths and resources which we may have missed or misjudged during our trip, and also to judge the faculty and administration's enthusiasm toward such a project, a significant ingredient. The information obtained from the universities during our visit is in Appendix B.

University/Institute Proposals

We decided it was best to send each of the Universities a letter requesting them to respond to a series of questions which would give us a better feel for their overall interest and capability for conducting a research program using the MAML. The cover letter and questions are contained in Appendix C. Full responses were obtained from Laurentian University and Ontario Research Foundation. McMaster University provided a letter with partial answers to the questions. The other Universities failed to respond to the letter indicating to us that they were not interested in the program.

From these facts we have made the following conclusions. Ontario Research Foundation (ORF) has the best diesel laboratory and general air pollution engineering capability to carry out future research with the MAML. McMaster University has the best overall university technical capability in both engineering and industrial hygiene/health related research although their

engineering capability and interest in a project such as this was not disclosed in answer to our November 1981 questions. Laurentian University has the closeness to the Sudbury area mines and the overall best motivation to do this type of research but lack the broad technical capability that McMaster University and ORF have built-up over a number of years. The best way to select the university or institute to operate the MAML might be to have each submit a technical and cost proposal for the first year of research. A specific scope of work to deploy would be prepared by CANMET. Each organization would then submit a proposal to do the work. The final selection would be made based on the best technical proposal.

Design Specifications

As a result of our trip to the mines and discussions with CANMET personnel, a preliminary design for the Canadian MAML was developed. The size of the trailer was determined by physical limitations of the mine. Rough guidelines for the ruggedness, weight, and general layout of the inside were established based on our experience with our MAML. Specifications for a gas sampling system, particulate sampling system, power system, computer system, and instruments were also determined. From discussions with CANMET personnel, it was decided to design the MAML for both ambient monitoring of diesel pollutants and pollution generated by blasting. It was decided that the MAML would initially be designed to monitor CO, CO_2, NO_x, SO_2 and particulate matter. These pollutants are the recognized diesel pollutants and real-time, precise and accurate laboratory instruments are available for these pollutants. Specifications for the instruments and specific instruments for each pollutant are in Appendix D. During the design phase of finalizing the MAML, these recommended instruments should be reviewed.

Recently a new tapered oscillating microbalance (TEOM) has been reported in the literature as a instrument for making real-time particulate mass concentration measurements (2). Results show good correlation with filter measurements. This instrument should be given further consideration during the design phase.

The overall design specifications for the MAML are presented in Appendix E. Table 1 contains a list of the different systems which comprise the MAML.

Figures 1 - 5 show interior and exterior views of the MAML. The instruments will be mounted in the two racks in the rear of the trailer. A door will allow access to the back of the instruments. The design is compact. A dropped floor is used in order to increase inside head room as much as possible. The table shown in the front is for the MAML's computer system. Cabinets near the ceiling are for storage of manuals, parts, tools, fittings, and other miscellaneous items. The power system and tanks with span and zero gases are mounted outside the trailer. Sample lines for air monitoring are brought through the trailer wall to the instrument manifold.

Table 1

Listing of MAML Systems.

The Trailer Itself

Provides shelter for instruments from the mining environment, electrical isolation from spikes and transients in the power supply, the plumbing required for gas and particulate matter sampling systems (including provisions for calibration gasses), an electric heater and lights, space for an operator, a table for the computer system, and cabinets for storage of supplies, tools, and other needed items.

The Gas Sampling System

Draws air through one of eight sample lines, selected by manual or computer control, and into a manifold where it will be distributed to the instruments. Also included in this system is the capability to select one of four calibration gasses or a clean air supply instead of a gas sample.

The Particulate Matter Sampling System

Draws air through a single large diameter sample line to an instrument which measures particle size distributions.

The Power System

Isolates the instruments and other electrical equipment from voltage fluctuations, spikes, and other transients usually found in a mine's power system. This system also transforms the higher voltage at the mine to 110 volts, and provides outlets, lights, a heater, and a rack mounted breaker panel for power distribution.

The Instruments

Will be mounted in two standard size equipment rocks in the rear of the trailer. A large door at the rear provides access to the back of the instruments for servicing. There will be instruments to monitor CO, CO_2, NO_x, SO_2, and particulate matter. Also included are several thermocouples and their amplifiers.

The Computer System

Is a general purpose microcomputer system complete with a data acquisition system. The computer will take data from the instruments, record it on a floppy disk, and at the same time display it in graphic form on a cathode ray tube (CRT). The computer will control sample line selections and the particulate matter instrument. The computer will also process the data it records, and be able to plot it on its printer.

RIGHT SIDE

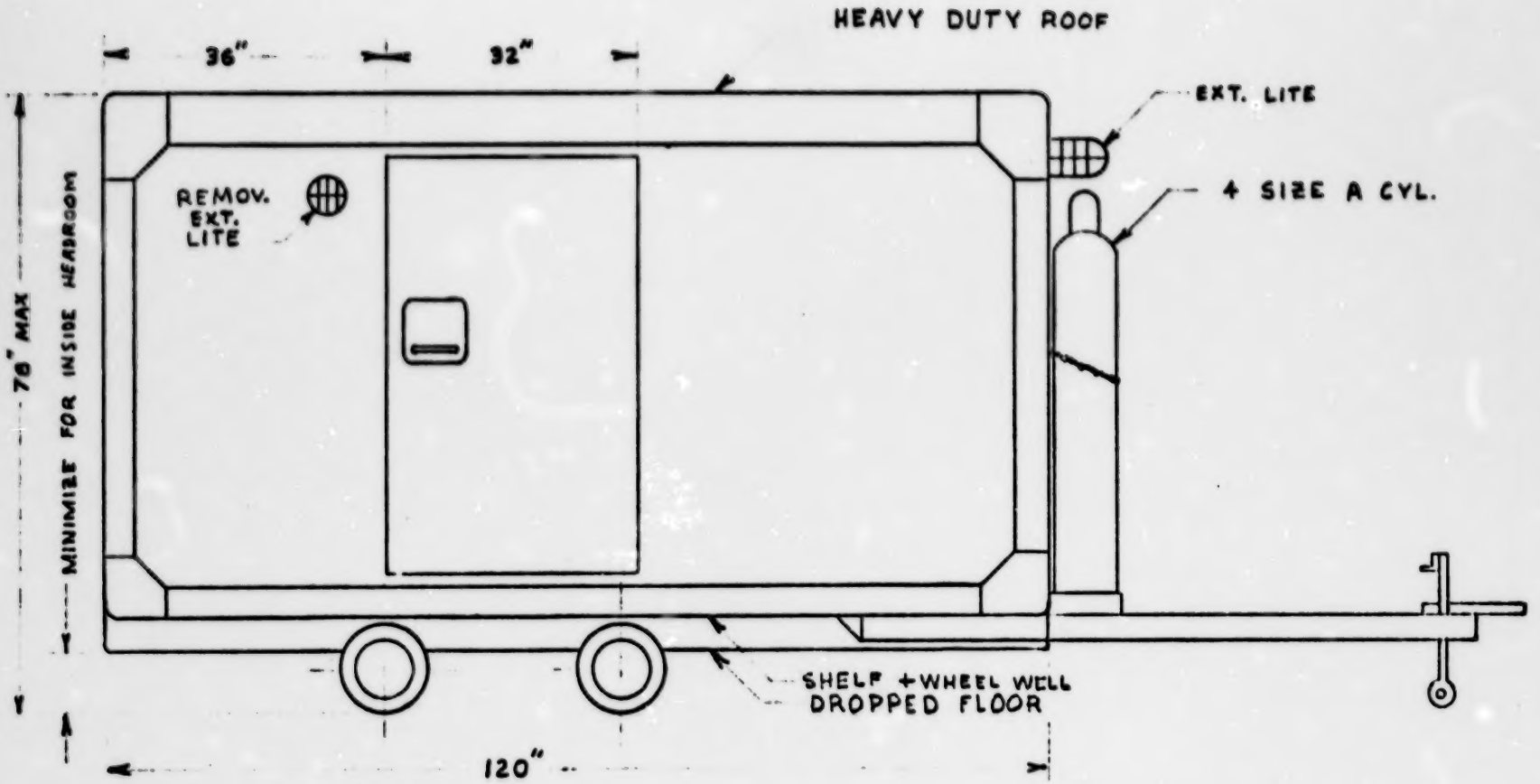

Figure 1 - Outside Right Side view of MAML

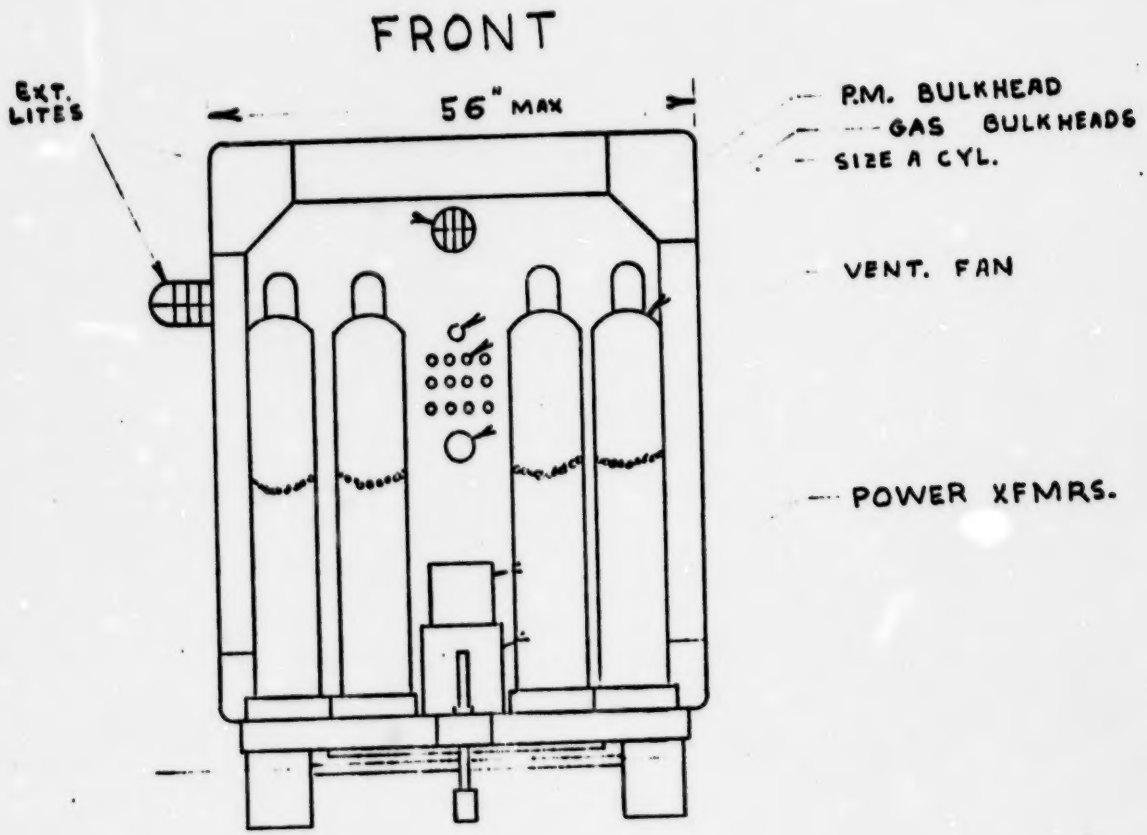

Figure 2 - Outside Front View of MAML

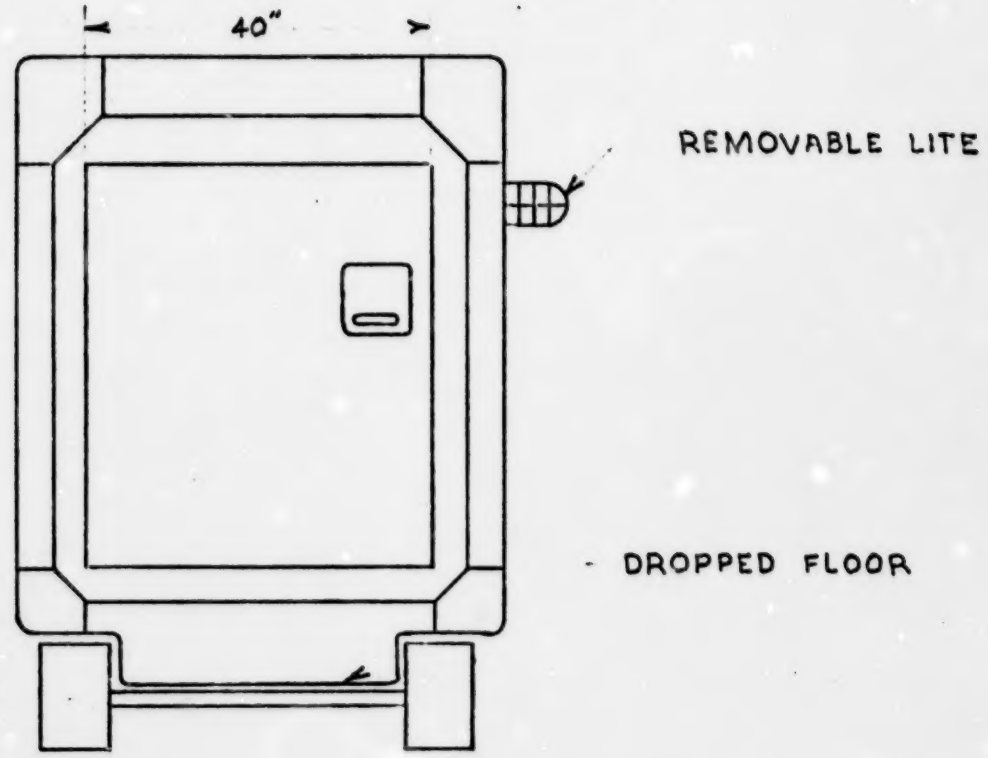

Figure 3 - Outside rear view of MAML

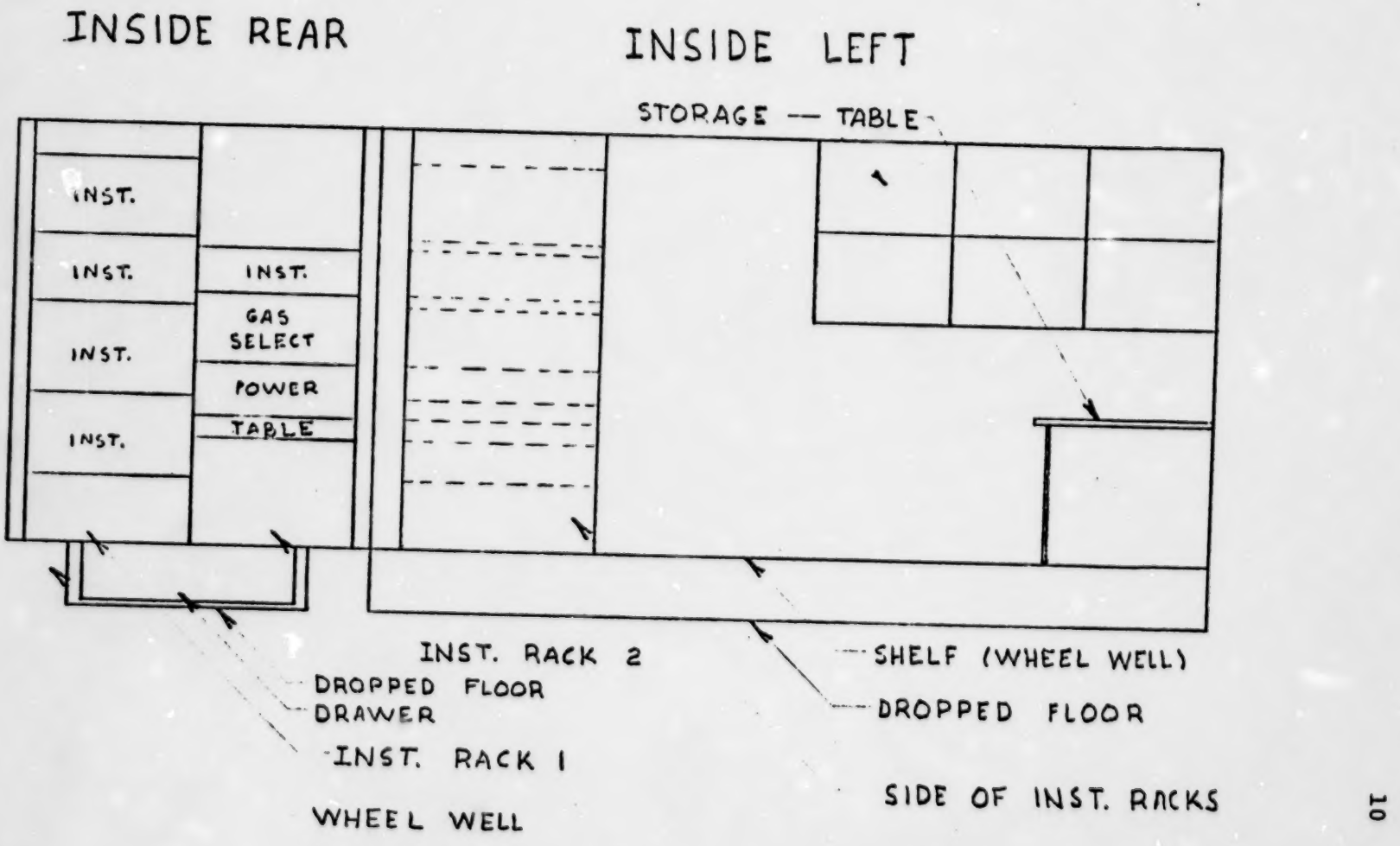

Figure 4 - Inside rear and inside left view of MAML

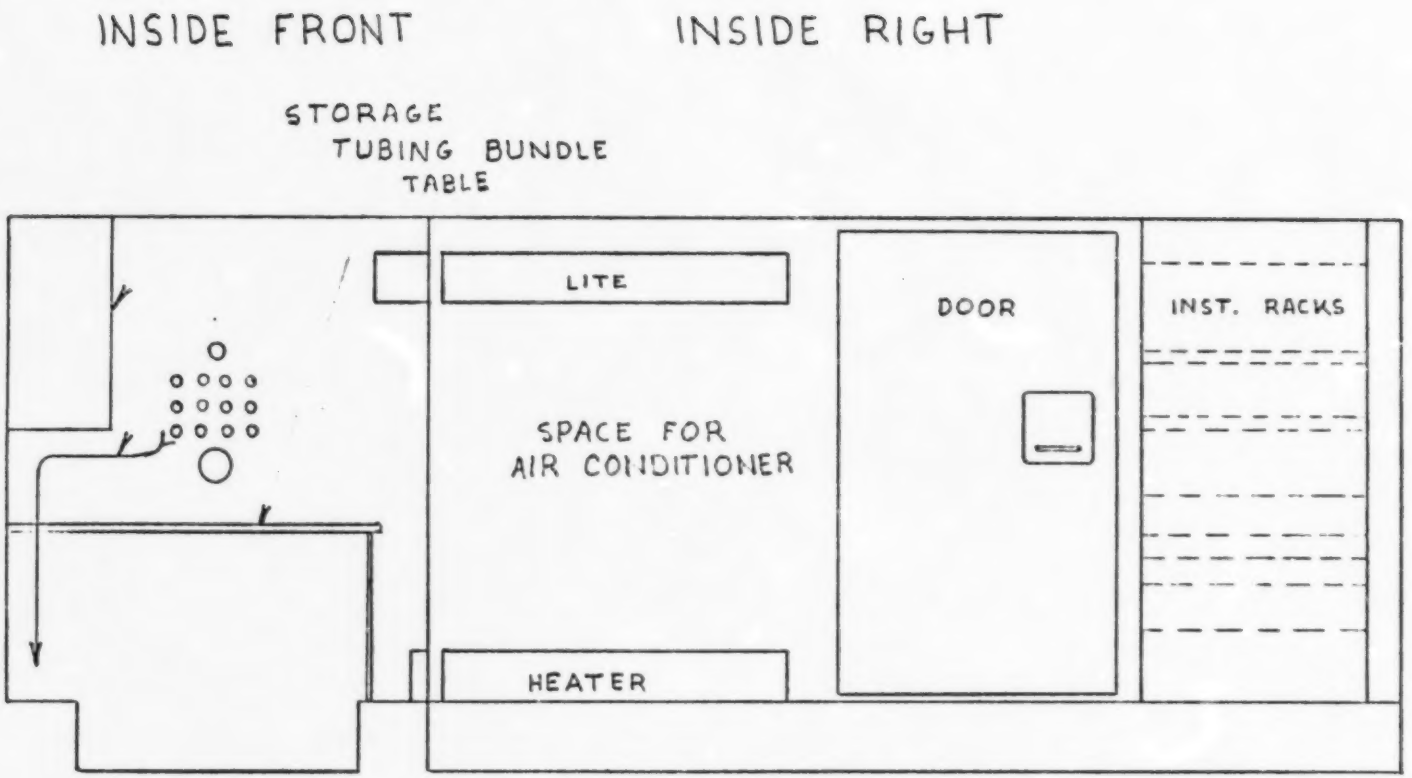

Figure 5 - Inside front and inside right view of MAML

The inside right view shows the door on the side that people will use for entry, a fluorescent light fixture, and a heater. The heater is an electric baseboard type and is required when the MAML is deployed in a cold area of the mine. Space has been left on this wall for a portable air conditioner which can be added later if the MAML is deployed in a hot mine environment.

We also considered a distributed type of system which would have portable gas instruments located in the drifts where the measurements were to be made, and send an electrical signal to the MAML where the computer was located. One such system that could be used this way is the Senturion 200 made by Conspec Controls. This system would be advantageous for two reasons. It could be used to monitor pollutants during production, and several channels could be dedicated to doing research in a test drift under controlled conditions. There is one main drawback to this system. Portable instruments, in the $1,000 to $2,000 price range, require daily maintainance and must be checked for drift every shift. Durability is also a problem. Our experience has been that even the more expensive laboratory instruments need a protected environment such as the MAML trailer provides.

If the state of the art of portable instruments advances in the future, a distributed system may be practical. This does not mean that the MAML would become obsolete. The MAML is versitile enough to be incorporated into such a system. Portable instruments, remotely located, could easily be wired to the computer in the MAML. Also, the MAML could be used to send data, in digital form, to a central site on the surface. It appears that suitable portable instruments (sensers) for all the pollutants desired will not be available for at least five years based on the present rate of development. Therefore, we think the proposed MAML is flexible for changing technology and will not be immediately obsoleted.

Visits to MAML Contractors

In December, 1981, we visited four potential contractors who could possibly design and build the Canadian MAML. These were Beckman Instruments, Barringer Research, Canadian Applied Technology, and MONITEQ. All four were located in the Toronto area. A booklet explaining our contract work and the preliminary design specifications was handed out. The criteria by which the contractors were to be evaluated were as follows (Appendix A):

1. Previous experience in building specialized instrument/data acquisition trailers

2. Project management capability (contacts with vendors and cost control included)

3. Mechanical and electrical design capability

4. Electronic design and computer-instrument interfacing capability

5. Mechanical and electrical technician and skilled trades capability

It was concluded that all four contractors visited would be capable of building the MAML, although each one had its own area of excellence.

This trip allowed us to further refine our specifications on the instruments, and get some insight from the people visited about possible problems which could develop due to the mine environment. This added information was incorporated into the revised specifications given in Appendix E.

CONCLUSIONS AND RECOMMENDATIONS

The present trend of cutting the Federal Budget in the United States could make the U.S. Bureau of Mines/MSHA MAML without support funds in the 1985 time frame. This is about the same time frame that the Canadian MAML would be operational. This factor must be considered in future CANMET planning.

The conclusions and recommendations based on this study are as follows:

1. Pollutants to be measured by the MAML are CO, CO_2, NO, NO_2, SO_2, and particulate matter. Provisions to measure particulate matter by a tapered oscillating microbalance (TEOM) can be incorporated into the design of the trailer and be added at a later date. These instruments provide the ability to calculate the Air Quality Index.

2. The recommended instruments are: Beckman NDIR Model 865 instruments for CO and CO_2; Monitor Labs Dual Chamber Model 8440E chemilluminescent NO_x instrument; Thermo Systems Model 3030 Electrical Particle Size Analyzer; Meloy Model SA700 Fluorescence instrument for SO_2 - more study should be given to SO_2 instruments during the design phase.

3. The recommended MAML design specifications includes a rugged designed trailer allowing for a man to sit in the MAML during testing and calibration. An Apple II Computer with 48k memory has been recommended for data acquisition and processing and control of the instrumentation.

4. INCO's South Mine appears to be ideally suited for the initial deployment of the MAML. Other mines could be used after the first three years of research.

5. Beckman Instruments, Barringer Research, Canadian Applied Technology, and MONITEQ are all qualified to design and construct the MAML. It appears that competitive proposals by all four organizations for the design of the MAML will be the best way to select a final design group.

6. Ontario Research Foundation (ORF), McMaster University, and Laurentian University all appear to be qualified to carry out future research with the MAML. Each has unique qualifications. ORF has the best present experience while McMaster University has the health related research capability for the long term integration of technology research with health related work.

McMaster's needs to develop their diesel engine emissions and mine ventilation capability in order to be successful in the long term. Only one contractor should be responsible for operating the MAML and carrying out research underground with the MAML and a instrumented LHD vehicle. The University or Institute that will operate the MAML should be brought into the design phase of the project. All three Universities/Institutes might be brought into the design phase followed by preparation of competitive research proposals for the first year of research during the time the MAML is being constructed.

7. Preliminary cost estimates indicate that approximately $110,000 (Canadian dollars) should be budgeted for instruments and equipment and $120,000 for manpower for the design, construction, supervision and consulting related to the design and construction of the MAML. In addition, approximately $35,000 should be budgeted for instrumenting a LHD vehicle with a CO_2 on-board instrument, engine speed, load and temperature transducers and a data acquisition system.

REFERENCES

1. D.E. Keski-Hynnila, E.O. Reinbold, and J.H. Johnson, "An Underground Mine Air Quality Laboratory for Studying Ventilation, Vehicle and Diesel Engine Pollutant Control Techniques", CIM Bulletin, Volume 74, No. 835, November 1981, pgs. 74-83.

2. S.A. Shimpi, et al "Real Time Diesel Particulate Measurement Using a Tapered Element Oscillating Micro Balance, SAE Paper No. 820463, Presented at SAE International Congress and Exposition, February 22-26, 1982.

APPENDIX A

Criteria for Judging Universities, Mines and Contractors to Design & Build MAML

CRITERIA FOR SELECTING MINE

1. Management's attitude about research and government work.
2. Representative of typical mining operations in Canada.
3. Good entry to mine for equipment.
4. Area suitable for study--Non-production, up and down sloping drifts, independent of changes caused by production, power availability, size of drifts and road conditions to area.
5. Equipment availability--Research vehicles and transportation to research area.
6. Distance to university.

CRITERIA FOR SELECTING UNIVERSITY

1. Interdisciplinary capability to do research--has mining, mechanical, instrumentation, chemical, and computer capability.

2. Shop, lab, computer facilities.

3. Administrative support and faculty interest/ Capability to do mine air quality research.

4. Location relative to potential mines.

Criteria for MAML Design and Build Contractors

Previous experience in building specialized instrument/ data acquisition trailers.

Project management capability (contacts with vendors and cost control included).

Mechanical and electrical design capability.

Electronic design and computer-instrument interfacing capability.

Mechanical and electrical technician and skilled trades capability.

APPENDIX B

University and Mine Fact Sheets

Denison Uranium Mine

Chakravatti, J. L.	Sr. Environmental Engr.	705-848-9111
Swan, Dale	Ventilation Engineer	705-848-9111 Ex. 241
Lehoux, Denis	Ventilation Engineer	Ex. 206
Ricaby, Al	General Manager	Ex. 200

Elliot Lake Labs

Tervo, Reino	Manager	705-848-2236
Knight, Geoffrey	Dust Research	705-848-2236

Rio Algom Mine

Black, Ken	Mining Engineer	705-848-7164

Strathcona Mine - Falconbridge

Storbeck, Jurgen	Plants Vent Supervisor	693-2761 Ex. 3212
Sebok, Karl	Project Analyst - Strathcona	693-2761 Ex. 6820
Musson, Martin	Supt. Mine Planning & Control Engineering	693-2761 Ex. 2386
Esche, Arnold R.	Chief Planning Supervisor	693-2761 Ex. 2467
Riddell, Joe	Fraser Mine Project Supt.	966-3411 Ex. 3371
Cornett, Don	Supt. - Strathcona Mine	966-3411 Ex. 6642
Cousins, Mike	Training Sup. - Diesels	675-1000 Ex. 215
Konowalchlik, Harold	Supt. - Ventilation	693-2761 Ex. 2167
Weglo, John K.	Director Environmental Control	693-2761 Ex. 2133
Calvert, S. W.	Strathcona Mine - Mech.	966-3411 Ex. 6633
Schultz, Steve	Strathcona Mine Ventilation	966-3411 Ex. 6687

South Mine - INCO

Ricketson, J.	Mine Supt.	682-2321
Soltendieck, H. F.	Mine Eng.	682-0380
Kitchener, L. C.	Mines Equipment Engr.	682-5256
Coulter, M. C.	Mines Vent. Engineer	682-5266
Schwedhelm, R.	CCSM Ventilation Supervisor	682-2061
Friesen, Menno	Area Engineer	682-2693
Elliott, Bill	Supervisor - Envr. Control	682-2488

Big Nickel Mine

Pearson, Dave	Project Director - Sudbury Science Center	
Jewiss, Tom		

Mine Worksheet

South Mine - International Nickel Co., Sudbury area

Material Being Mined, Mining Method, Rock Type:

Nickel, copper, precious metals. Iron not economically feasible. Blast hole stoping between levels to remove ore. Vertical retreat. Muck pile is right at drift. Mine is totally flat (°0) multilevel. Hard rock typical of Sudbury area.

Mine Entry & Dimensions of Drifts:

Cage: 58 inches wide x 81 inches high x 12 feet long.
lower cage is somewhat smaller.
slinging possible - 1 ft. wider than cage.
Portal entry for equipment to 750 ft. Will be completed in 18 mo.
Drifts: 20 ft. wide x 12 ft. high (nominal), 8.5 ft. high minimum.

Power:

575 volts 3ϕ 60 Hz

Road Characteristics:

Clear roads - straight and wet at 0° incline (flat)

Temperature & Humidity:

60°F nominal
65-72% humidity on level, 90% average

Mining Machines Used:

Wagner ST5	Deutz 175 hp exhaust → catalytic converter → muffler → out both sides
Jarvis JS500	Deutz 175 hp same as above
Wagner ST8	Deutz 222 hp V10 exhaust → catalytic converter → muffler → out bottom forward and aft (protective plates)
Creighton Diesels	8 - 70 hp and 10 - 90 hp.

Ventilation Methods:

Air moves in on even levels, out on odd ones. Finding suitable test drift may be difficult because of this method. Some permanent fans in tubes - 36 inch diameter 20,000 CFM. Fan and tubing 60 ft. from face. Moved back to 125 ft. for blasting. Tramming driver would directly benefit from MTU modified exhaust in haulageway.

Mine Worksheet

Strathcona Mine - Falconbridge, 45 minutes north of Sudbury

Material Being Mined, Mining Method, Rock Type:

Nickel, copper, precious metals. Iron not economically feasible. Multilevel tracked mine on vertical ore body. Levels and stopes are flat (0°). Mining is done in irregular "pods" or groups of stopes. Stopes are 42 ft. wide, 15-20 ft. high, and up to several hundred ft. long. Hard rock typical of Sudbury area.

Mine Entry & Dimensions of Drifts:

Cage entry only. Dimensions 5 1/2 ft. wide x 10 ft. high x 13 ft. deep. Ventilation door frames 6 ft. wide x 6 1/2 ft. high. Has upper and lower cages. No slinging possible. Trackless drifts: 20 ft. wide x 10 ft. high, 8 ft. high minimum. Tracked drifts: nominal 8 ft. x 8 ft.; minimum 6 1/2 ft. high x 7 ft. wide.

Power:

575 volts 3ϕ 60 Hz

Road Characteristics:

Rubble and rocks in roundway - need 12-18 inches clearance will be hard for small tires, may need to use a skid. Main trackless haulageway very clean and flat, concrete with drains.

Temperature & Humidity:

Approx. 68°F. Intake air heated in winter. Humidity varies from very dry in stopes to 100%.

Mining Machines Used:

Jarvis JS500	Deutz V8 175 hp exhaust → catalytic converter → muffler → out and down both sides
Wagner ST5	Deutz V8 175 hp same as above
Wagner ST4	Deutz 125 hp exhaust → catalytic converter → muffler → out both sides
Wagner ST2	Deutz 6 cyl. 78 hp exhaust → catalytic converter → muffler → out rt. side near floor

Ventilation Methods:

Poor definition in pods in general than other mines. Has well defined system of "air draws" from level above in conjunction with fans and tubing. Exhaust buoyancy considerations show promise. Use 19 and 24 inch jet fans (10,000-12,000 CFM) with tubing 40-50 ft. from face. Whole mine - 30,000 CFM. MTU modified exhaust would work well in main haulageway.

Mine Worksheet

Denison Mine - North of Elliot Lake

Material Being Mined, Mining Method, Rock Type:

Uranium ore. Method is pillar and stope; small stopes very near drifts penetrate 50-100 ft. and are generally up sloping. One body in hard quartzite rock gives irregularly triangular or wedge shaped face. Ore body is generally bowl shaped. Has both up and down sloping drifts.

Mine Entry & Dimensions of Drifts:

Two shafts. #2 larger than #1. Only entry through cage. Heavy equipment is slung below cage. Scooptrams taken down by pieces. No cage dimensions available. Drifts: 12 ft. high x 20 ft. wide nominal. 10 ft. high minimum.

Power:

575 volts 3ϕ 60 Hz

Road Characteristics:

Clean and wide, maximum slope 20°, ground clearance - no problem.

Temperature & Humidity:

Approx. 68°F. Intake air is heated in winter. Humidity averages 80% summer, drier in winter.

Mining Machines Used:

Jarvis JS800 Tram	Detroit diesel 2 stroke water cooled
Wagner ST8 Tram	Deutz 222 hp 4 stroke air cooled
Jarvis JTD426 One car	

All have exhaust → catalytic converter → muffler → out bottom right side.

Ventilation Methods:

Extensive use of fan and tubing 50-100 ft. from face using 30,000 CFM jet fans. Very good ventilation for a hard rock mine. 4.5 million CFM air moved total: 4 exhausts, 3-4 inlets.

Mine Worksheet

Big Nickel Mine - Sudbury Science Center

Material Being Mined, Mining Method, Rock Type:

Not a commercial mine. Presently used for tourists. Mining method old - small drifts connect to small stopes. Very small workings - plan to expand part for diesel machines. Rock typical of Sudbury area.

Mine Entry & Dimensions of Drifts:

Cage and Adit 8 ft. x 8 ft. adit entrance and drifts. 6' minimum roof height. Plan to add portal entrance with 12 ft. x 14 ft. drifts. Have 600 - 800 ft. by May, '82.

Power:

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Road Characteristics:

Tracked roads clean and free of obstructions. Present mine too small for MAML but expansion will accommodate MAML.

Temperature & Humidity:

50°F (cold), 60-80% humidity

Mining Machines Used:

Some old machines on display for tourists. Not a working mine.

Ventilation Methods:

Too early for ventilation plan.

University Worksheet

Laurentian University

August 14 Afternoon

Relative Size of University:

2500 total students, 300 in science and engineering; 9 faculty in science and engineering; Mining and Mineral Processing are the only 4 year programs in science and engineering; College of Sciences offers masters degree; Have a person who has done mine air pollution studies; Departments (2 year): Mechanical, Chemical, Civil; No graduate students.

Research Done by University:

Biology department has worked with INCO with Government supplied money; almost all faculty involved and publishing; promotion dependent on research.

Technical Capability to Support MAML:

Good lab equipment, chemistry department, and Industrial Hygiene in dust; shop facilities questionable; technical help poor - only 1 technician available; may have staffing problem for MAML.

Computer:

IBM 360/40 medium sized for FORTRAN and Administrative work.
DEC 2020 used for teaching and research
No support personnel for software work; No data transfer capability yet; No graphics.

Mining Company Affiliations and Distance:

Very close to several feasible mines; historically involved with Industry very much; involved in mining and uses people from industry as lecturers; close to INCO and Falconbridge.

General Comments:

This school is small, but has an enthusiastic faculty who know they must have a good attitude for the school to succeed. The small size gives an advantage in interdisciplinary work. The biggest problem here is lack of support staff.

University Worksheet

McMaster University - Toronto Area

August 18, Morning

Relative Size of University:

10,000 full time students, 10,000 part time students; Departments: Mechanical, Electrical, Chem. Eng., Comp. Sci., Ceramics, Chemistry, Metallurgy; very oriented to the medical field, with M.D. program, health services dept., bioengineering, and a hospital.

Research done by University:

Employ some full time staff for research, including 3 analytical chemistry professors; receive much support from province for programs; project: Mutagenic studies of foundry emissions; research direction follows the dollars; project: sub-micron particles and effects on human lungs.

Technical Capability to Support MAML:

Lab facilities are outstanding; technical help available from bioengineering: 6 technicians and 1 electrical engineer staff instrumentation; shop facilities are well equipped; separate student facilities.

Computer:

Large CDC 6400 mainframe for FORTRAN processing
Large HP3000 system
Apple microcomputer
Graphics scope, versatek and pen plotters; no presently known data acquisition system for MAML.

Mining Company Affiliations and Distance:

Not close to any applicable mines; no mining department.

General Comments:

A very modern school with strong direction in the medical area and a lot of government sponsored interdisciplinary research.

University Worksheet

University of Toronto - Toronto, Ontario

August 18, Afternoon

Relative Size of University:

50,000 total students, 2500-300 engineers; 2 sattelite campuses in Toronto; large graduate school - 30% of students are graduate students; departments: Mechanical, Electrical, Chem. Eng., Comp. Sci., Chemistry, Chem. Eng., Civil Eng.

Research Done by University:

No lack of dollars or research projects here; very strong interdisciplinary work - many joint appointments; project must be interesting to faculty to be considered.

Technical Capability to Support MAML:

Lab capability appears good due to size of school and amount of equipment; technicians readily available for custom work and instrumentation; good shop facilities, each dept. has its own; ME dept. has research engineers for projects.

Computer:

2 IBM 3033 mainframes, 2 VAX mainframes for FORTRAN
PDP 11/23 (w/floppy) with data transfer programs applicable to MAML; HP data acquisition systems; many micro compter systems around; don't know about graphics facilities.

Mining Company Affiliations and Distance:

Not close to any applicable mines; no mining department, but used to in 1960's; now an option in Geology dept., may be developed again.

General Comments:

A fairly large school, involved in a diverse range of projects; U. of Toronto has tremendous resources, and apparently does a lot of research; our impression was that faculty enthusiasm for a project was an important factor here.

University Worksheet

Queens University - Kingston, Ontario

August 19, Morning

Relative Size of University:

10,000 total students, 1700 in applied sciences; departments: Mechanical, Electrical, Chem. Eng., Comp. Sci., Mining, Chemistry, Eng. Physics, Math, and Drawing; very strong in mining, has Medical Health dept.

Research Done by University:

Volume has increased strongly in last 5 years; promotion and tenure depend strongly on research activity; many research contracts in mining dept.; blasting test site 35 miles away is heavily instrumented.

Technical Capability to Support MAML:

Lab capability assumed to be good due to Medical Health dept.; some technicians, possibly weak here for instrumentation; shop facilities no problem; some people doing real time work already.

Computer:

10 dedicated analysts in computer services; 2 IBM 4341's mainframe for FORTRAN; coming soon - VAX-78 mainframe for FORTRAN; engineering departments have their own small machines, about 100 small DEC machines, PDP 11/23, LSI-11; data acquisition system exists but may need to be changed for MAML; graphics scopes (26), hardcopy units, Versatek and pen plotters.

Mining Company Affiliations and Distance:

Queens works with industry - has worked with Denison Mines before; not close to any applicable mines; big in mining.

General Comments:

Queens is a small school, but very strong in mining; they have a remodeled engine testing facility, and good industrial hygiene; small size gives it an advantage for doing inter-disciplinary research and interdepartmental interactions.

University Worksheet

University of Laval - Quebec City, Quebec

August 20, Morning

Relative Size of University:

24,000 total students, 3000 engineering and science students; mostly an undergraduate school; departments: Mechanical, Electrical, Mining, Chemical, Geology, Comp. Sci., Metallurgy; very big in ore dressing and metallurgy; big in mining.

Research Done by University:

Ph.D. student working on diesel exhaust emissions; have done work for both industry and government; research encouraged for promotion; some faculty only do research; funding is on the increase; have some ties with government on research projects.

Technical Capability to Support MAML:

No indication of lab capability; each dept. has its own shop facilities; one large central one; have 8 technicians available + 2 engineers for instrumentation; have industrial hygiene people.

Computer:

2 IBM 4051 mainframes, VAX mainframe for FORTRAN; data transfer capability currently being worked on; have software people - do ore dressing simulations; graphics scopes, 2 pen plotters, digitizing tablets; data acquisition with PDP-11, PDP-8, and MINC-11 systems.

Mining Company Affiliations and Distance:

Not real close to any applicable mines but mines in general vicinity; 80% of mine managers come from Laval due to practical experience gained at this school.

General Comments:

Laval is big in mining; has some industrial hygiene, and good computer support; they were very enthusiastic about the MAML.

University Worksheet

McGill University - Montreal, Quebec

August 20, Afternoon

Relative Size of University:

20,000 total students, 2000 science and engineering undergraduates; departments: Mechanical, Electrical, Mining, Chemical, Comp. Sci., Occupational Health and Safety, Metallurgy; big in medicine; offers masters and Ph.D. degrees.

Research Done by University:

ME dept working on diesels; have remote wind tunnel; lots of government sponsored research done here; new Occupational Health and Safety Institute (particles, gasses, and vapors); 5 year effort; research attitudes balanced; some faculty do mainly research; some only teach or do administrative work; all 3 used to judge promotion.

Technical Capability to Support MAML:

Lab facilities good due to medical and industrial hygiene and school size; good shop facilities; rely on EE dept. for technical help; could be a problem here in getting a dedicated person.

Computer:

Amdahl 470 mainframe for FORTRAN; no data transfer capability; would have to be built; some departments have micro computers which are used as terminals, but no general purpose data acquisition systems around; no graphics terminals; have a pen plotter.

Mining Company Affiliations and Distance:

Not close to any applicable mines; not much information on mining department or activities.

General Comments:

McGill is fairly large, and the new facility for industrial hygiene is significant; there is a lot of research going on here; we wondered if ther may be a problem getting interested researchers here.

APPENDIX C

University/Institute Questionnaire and Proposals

Energy, Mines and Resources Canada
Science and Technology

Énergie, Mines et Ressources Canada
Science et Technologie

Your file Votre référence

Our file Notre référence
Pr. No. 4.3.0.2.04

November 9, 1981.

As you are aware, Professor John Johnson, on behalf of the Department of Energy, Mines and Resources, has been conducting a survey to locate a suitable institute or organization with the required infrastructure to support a research program using a Canadian version of his Mines Atmosphere Monitoring Laboratory (MAML).

In order to flesh out the information gained in his initial visit, Professor Johnson has prepared the enclosed questionnaire. If your organization has seriously considered working with the MAML, could you respond to the questions by December 15, 1981. (The feasibility study must be completed within FY81-82, so Professor Johnson will not be able to include information received after that date in his analysis).

Please forward one copy of your reply to:

Paul Mogan,
Mining Research Laboratories,
CANMET
c/o 555 Booth St.,
Ottawa, Ontario. K1A 0G1

and a second copy to:

Professor John H. Johnson,
Box 39A,
Royalwood Addition,
Houghton, MI 49931
USA

Should you require further information, my number is 613-996-4570, ext. 127, and Professor Johnson's is 906-487-2576. Thank you for your co-operation.

Sincerely,

Paul Mogan

Canada Centre for Mineral and Energy Technology,
555 Booth Street,
Ottawa, Canada.
K1A 0G1

Centre canadien de la technologie des minéraux et de l'énergie,
555, rue Booth,
Ottawa, Canada,
K1A 0G1

Questions to be addressed by University Response

1. What team of individuals would you propose to carry out research with the MAML? Be specific relative to individuals (resumes) or description of education and experience of those individuals you might hire for the project. What project organization would be used to manage the project?

2. What research do you feel needs to be carried out with the MAML? Be specific based on a critical review of the literature.

3. What mines would you feel to be best suited for working with you on this project? Give specific reasons why you recommend this (these) mine(s).

4. Describe in detail your present and planned computer capability. How would you want the real time data recorded in the MAML or on the instrumented vehicle? How would you handle the data to get it into your digital computer for analysis and plotting? What is the estimated cost of hardware or programming for getting the data into the digital computer? Describe your plotting and computer graphics capability.

5. Describe equipment, instrumentation and support personnel in various labs that might be useful on this project. Be specific where this (these) lab(s) might be useful for the research.

6. Describe other related research that you have underway or have completed that would be technically complimentary or would show your capability to undertake research of this nature.

APPENDIX D

Recommended Instruments and Ranges

Instruments Requirements

Rugged enough to withstand the environment.

Canadian servicing preferable.

Fast response time - 90% in 10 seconds or faster.

Zero or span drift within 1% of full scale in most sensitive range in 24 hours.

NO, NO_2, NO_x, instrument must be a dual cell unit for real time measurements. Chemilluminescent detection method.

CO, CO_2, instruments should be non-dispersive infrared.

SO_2, instrument should be pulsed fluorescence.

Particulate matter, should be able to make multiple repeatable measurements as close to real time as possible.

Ranges:

For Ambient Air Monitoring Only:

CO: 0-10, 50 ppm

CO_2: 0-0.5%

NO_x: 0-1, 5, 10, 50 ppm

SO_2: 0-1, 5 ppm

PM: 0-6 mg/m^3; .01-1 μm

For Blasting:

CO: 0-10, 50, 250, 500, 2500 ppm

CO_2: 0-0.5, 2, 5%

NO_x: 0-5, 10, 50, 100, 250 ppm

SO_2: 0-5, 20, 200 ppm

Recommended Instruments:

1. Beckman NDIR model 865 CO_2 instrument. Rise time 90% in 1/2 second, ranges may be modified to 0-0.5, 2, 5%. Drift: $\pm$ 1% of full scale in 24 hours.

2. Beckman NDIR model 865 CO instrument. Rise time 90% in 1/2 second. Our range specifications may require a dual cell instrument. Drift: $\pm$ 1% of full scale in 24 hours.

3. Monitor Labs Dual chamber model 8440E chemillumenscent NO, NO_2, NO_x, instrument. Rise time 90% in 2.3 seconds. Extended ranges may be obtained to our specifications.

4. Meloy model SA700 Fluorescence SO_2 instrument. Rise time 95% in 90 seconds. Zero drift: 3ppb in 24 hours. Span drift: maximum 3% of full scale.

5. Thermo Systems Incorporated model 3030. Electrical particle size analyzer. Measurement time: 2 minutes/cycle. Particle size ranges: 0.0032 to 1.0 micron.

APPENDIX E

Preliminary Design Specifications for MAML

Listing of MAML Systems

The Trailer Itself

Provides shelter for instruments from the mining environment, electrical isolation from spikes and transients in the power supply, the plumbing required for gas and particulate matter sampling systems (including provisions for calibration gasses), an electric heater and lights, space for an operator, a table for the computer system, and cabinets for storage of supplies, tools, and other needed items.

The Gas Sampling System

Draws air through one of eight sample lines, selected by manual or computer control, and into a manifold where it will be distributed to the instruments. Also included in this system is the capability to select one of four calibration gasses or a clean air supply instead of a gas sample.

The Particulate Matter Sampling System

Draws air through a single large diameter sample line to an instrument which measures particle size distributions.

The Power System

Isolates the instruments and other electrical equipment from voltage fluctuations, spikes, and other transients usually found in a mine's power system. This system also transforms the higher voltage at the mine to 110 volts, and provides outlets, lights, a heater, and a rack mounted breaker panel for power distribution.

The Instruments

Will be mounted in two standard size equipment rocks in the rear of the trailer. A large door at the rear provides access to the back of the instruments for servicing. There will be instruments to monitor CO, CO_2, NO_x, SO_2, and particulate matter. Also included are several thermocouples and their amplifiers.

The Computer System

Is a general purpose microcomputer system complete with a data acquisition system. The computer will take data from the instruments, record it on a floppy disk, and at the same time display it in graphic form on a cathode ray tube (CRT). The computer will control sample line selections and the particulate matter instrument. The computer will also process the data it records, and be able to plot it on its printer.

Overall Trailer Specifications

Overall dimensions are shown on drawings on following page.

Approximate total weight--5000 pounds.

To be of extremely heavy duty construction.

Heavy duty frame and suspension. Double axle.

Roof reinforced with 6" plywood--able to support two men and withstand 20 pound rock falling six feet.

Dropped floor (or detachable chassis with outboard wheels and no dropped floor) to maximize inside head room. Ground clearance not critical.

Large wheels, tubed tires.

Sway bars, skid plate, and electrically controlled surge brakes.

Low volume positive pressure ventilation system.

Road legal with lights and mine approved.

Large door in rear for access to equipment.

Side door for access by personnel.

Two standard 19" instrument racks mounted in rear inside.

Racks for four size A cylinders up front.

Insulated.

Two outside mounted incandescent lights.

Inside table in front of trailer.

Mounted cabinets inside near front on left side.

Gas Sampling System

Eight ¼" I.D. teflon lines with fittings. Length to be determined.

Eight filters for line intakes.

Eight bulkhead mounts through front wall of trailer.

Manifold for gas distribution to instruments.

Stainless steel lines to be used inside trailer to valves and manifold.

Teflon lines to be used from manifold to instruments.

Valves as shown in drawing on next page.

High volume bypass pump with trap and flow control valve.

Sample pump.

Air cleanup system to provide zero gas for NO_x instrument.

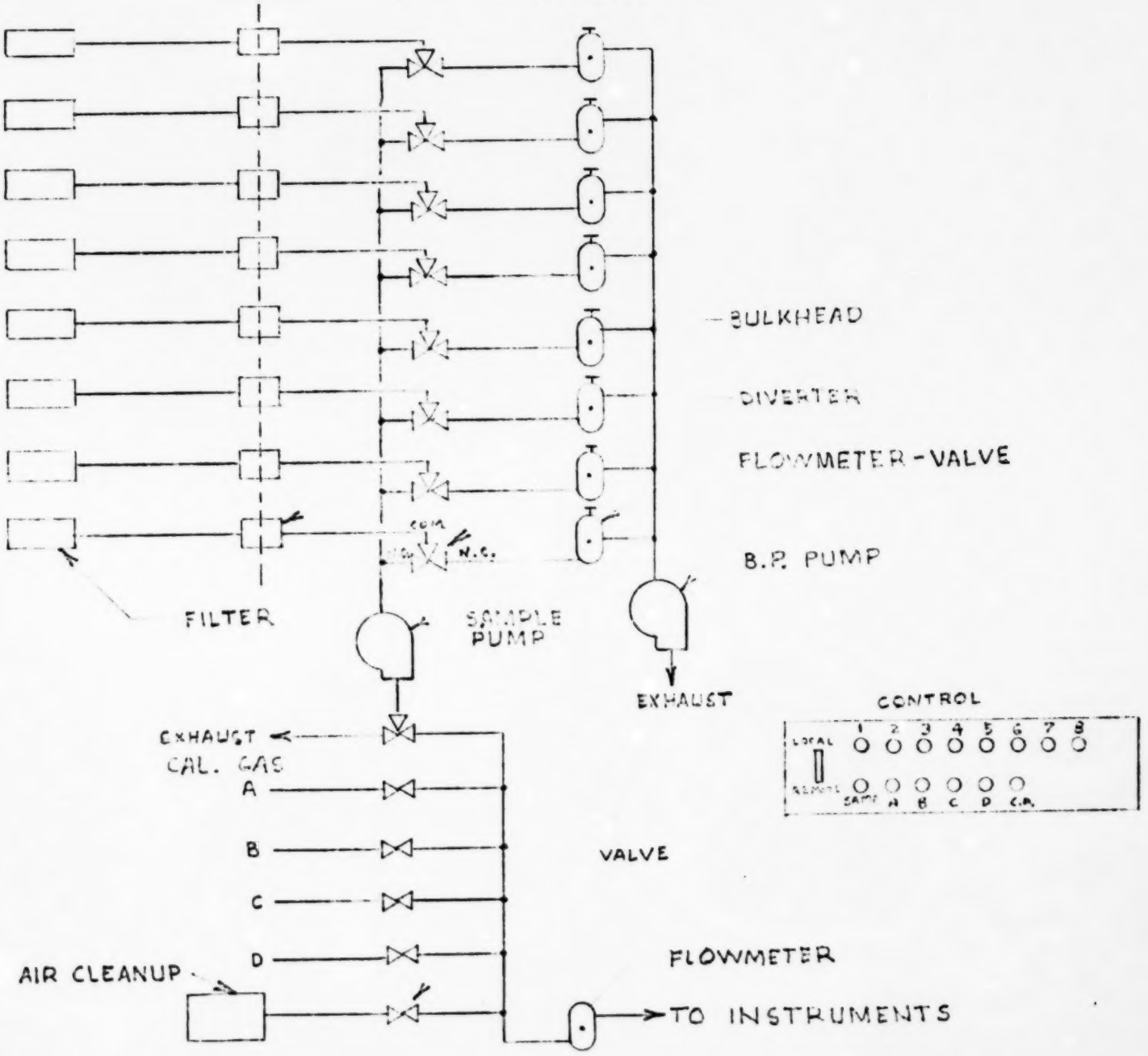
Regulators, tubing, fittings, and bulkhead mounts through front of trailer for four calibration gasses.

Flow meters with flow rate valves mounted in rack.

Control unit mounted in rack selects one of the eight sample lines, four calibration gasses, or clean air under manual or computer control.

Diagram shown on next page.

GAS SAMPLING SYSTEM



Particulate Matter Sampling System

Sample line 1.25" I.D., in sections with fittings. Length to be determined.

Bulkhead mount through front trailer wall.

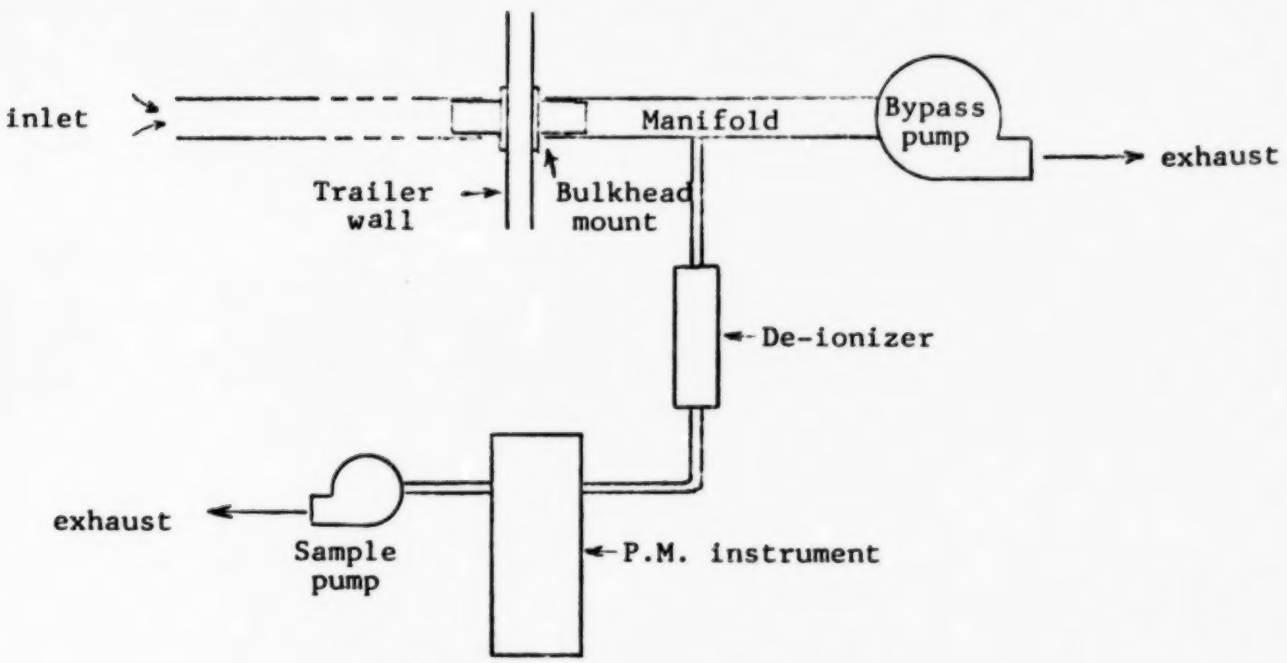
Manifold.

Bypass pump--high volume.

Sample pump--vacuum.

Miscellaneous fittings and tubing.

Diagram of system:



Power System

Input: 575 volts 3 phase A.C. 60 Hz.

Output: 110 volts Single phase A.C. 60 Hz.

Estimated maximum power--25 kw.

Input connector.

Main power contactor.

Constant voltage transformer.

Auto transformer.

Voltmeter mounted in rack.

Isolation transformer for instruments and computer.

Breaker panel mounted in rack with separate circuits for lights, each rack, each pump, etc.

Several 110 volt outlets inside trailer and at computer table in front.

Electric heater.

Fluorescent interior light.

Incandescent outside lights.

Many 110 volt outlets in back of equipment racks.

Twelve volt trailer lights, wiring, and connector.

Computer System

Rugged enough to withstand environment.

Reliable.

Replacement parts availability.

Powerful enough to process data.

Compatable with data acquisition system.

Graphics capability with hard copy.

Disk storage medium.

Capability to communicate with another computer.

To sit on table at front of trailer.

Block diagram shown on next page.

Suggested System:

Apple II computer with 48K memory.

Two floppy disk drives, or one floppy disk and one Winchester technology disk.

Sharp color monitor CRT.

Micromodem communication unit.

ISAAC 16 channel data acquisition system.

Analog Multiplexing (Mux) unit.

Dot matrix printer--not Apple.

Software (ISAAC, VERSAPLOT, some locally written).

MAML COMPUTER